CASE STUDY OF POWER SYSTEM STATE ESTIMATION BY USING ARTIFICIAL NEURAL NETWORK

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"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Electronics)"

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ABSTRACT

This is a study that mains in Artificial Neural Network technique which introduces approach towards the problem of errors that arise due to the practical equipment and actual measurements in distribution systems. Real time data or the state variables measured in power system are often incorporated with error. This project outputs a software program that performs power system state estimation using artificial intelligence optimization. It was developed using Artificial Neural Network in MATLAB software. This method considers nonlinear characteristics of the practical equipment and actual measurements in distribution systems. It can estimate bus voltage and load angle values at each node by minimizing difference between measured and calculated state variables. This is accomplished by the utilization of load flow analysis program which acts as computerized conventional solution that calculates mathematically the exact target outputs in accordance to the inputs applied. The significant functions of the developed software program also include the accurate estimation of power system state with insufficient input data applied. This project has successfully built a power system state estimation software program that perform accurate state estimation achieving desired outputs even when provided with insufficient input data magnitudes. It helps identify the current operating state of the system on which, security assessment functions and hence contingencies can be analyzed leading to the required corrective actions.

ABSTRAK

Projek ini mengkaji teknik Artificial Neural Network di mana ia menyelesaikan masalah yang disebabkan oleh ralat pengukuran dalam kemudahan di system rangkaian pengagihan kuasa. Angka parameter yang diukur dalam system kuasa sebenar biasanya mengandungi ralat. Project ini bertujuan menghasilkan program perisian yang berfungsi menganggar parameter dalam system kuasa dengan menggunakan teknik kepintaran artifak. Program perisian ini ditulis dalam perisian MATLAB dengan menggunakan teknik Artificial Neural Network. Teknik ini mempertimbangkan aspek- aspek ketidakselarasan kemudahan dalam system rangkaian pengagihan kuasa. Program ini mampu membuat penganggaran nilai voltan bas dan sudut beban pada setiap nod dengan meminimakan perbezaan antara nilai pengukuran dan pengiraan secara theory. Kebolehan ini dicapai melalui penglibatan pelaksanaan program yang menganalisa nilai- nilai pengaliran beban menggunakan cara pengiraan lama dengan menggunakan computer di mana ia memberi keputusan nilai yang tepat berdasarkan teori. Program ini juga berkebolehan untuk membuat penganggaran dan memberi nilai keputusan yang tepat tanpa memerlukan bekalan data yang sempurna. Secara kesuluruhannya, projek ini telah berjaya menghasilkan program perisian penganggaran nilai parameter semasa sistem kuasa yang berkesan mencapai ketepatan nilai keputusan yang tinggi walaupun tanpa dibekalkan data yang memadai. Program perisian ini membantu mengesan nilai semasa system operasi di mana penilaian fungsi keselamatan dalam operasi system kuasa dan justeru kesan- kesan awal kegagalan dapat dianalisakan supaya tindakan pembetulan atau pembaikan dapat dilaksanakan.

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CHAPTER 1

INTRODUCTION

The advancement in computer and communication technologies has resulted in wide application of the supervisory control and data acquisition (SCADA) system in the modern control centers. SCADA is highly capable and flexible that it deals with large information flows coming from many protective and control devices placed in the bulky electric power systems.

By processing the real- time redundant measures and network parameters available in the SCADA database, the state estimation obtains current states of system. Therefore, the performance of state estimation relies on the accuracy of the measured data as well as the parameters of the networks model.

1.1 Power System State Estimation

Power System State Estimation is a calculation to estimate the power system state by using EMS(Energy Management System). The aim of the state estimation is to get the best estimate of the current system states processing a set of real-time redundant measures and network parameters available in the database. The performance of state estimation, therefore, depends on the accuracy of the measured data as well as the parameters of the network model. The measured data are subject to noise or errors in the metering system and the communication process. Large errors in the analog measurements, so-called bad data, may happen in practice[6].

Network parameters such as impedances of transmission lines may be incorrect as a result of inaccurate manufacturing provided data, error in calibration, etc[2]. In addition, due to the lack of field information and possible errors in calculations, transformer tap positions may be erroneous. The purpose of a state estimator is to filter all these errors to achieve the best possible estimate of the state of the system[8].

Generally, WLS (Weight-Least-Square) estimator or non-Gaussian estimator is used to determine the state of the system. Few estimation is use for example Maximum Likelihood Estimation, General State Estimation is use to minimize the bias of the power system state[2].

1.2 Problem Statement

Despite the convenience provided by the SCADA system, however, there are errors that arise due to the practical equipment and actual measurements in distribution systems. For instance, noise in metering system and communication process, large error in analog measurements that may happen in practice, erroneous transformer tap positions due to the lack of field information and possible errors in calculations, inaccurate manufacturing provided data, error in calibration and so on.

1.2.1 Load Flow Analysis

The conventional way, i.e. Load Flow Analysis requires complete set of data or input and takes time to mathematically perform. Though programs created to replace hand calculation are available nowadays and they successfully save a lot of time, but still, they need complete set of input data in order to run and achieve the desired outputs[12].

Therefore, this study proposes a power system state estimation method using an AI optimization, for example Artificial Neural Network (ANN) which can estimate bus voltage and load angle values at each node by minimizing difference between measured and calculated state variables. This method aims to filter the errors mentioned earlier so that the best possible estimate of the system state is achieved[15].

1.3 Objectives

This project aims to produce a software program that performs power system state estimation with the application of Artificial Neural Network. The software program should output results instantly after the inputs are given or in other words it takes shorter time to perform as compared to the hand calculation method for Load Flow Analysis.

Without requiring complete input parameters data it has to perform state estimation and achieve desired output. It should estimate bus voltage and load angle values at each node by minimizing difference between measured and calculated state variables that it aims to filter the errors at the same time considering the nonlinear characteristics of the practical equipment and actual measurements in distribution systems so that the best possible estimation of the system state is achieved.

1.4 Scope Of The Project

The related scopes of this project are Artificial Intelligence (AI), Artificial Neural Networks (ANNs) and MATLAB software. It involves data collection, training and testing phases. The training phase utilizes supervised learning technique and the weights or strengths of connections in the artificial neural network are automatically adjusted according to some modification rules.

MATLAB Software is utilized where .m file as the location to write program and form linkages between main program and sub programs, also, as the platform where ANN program is trained to be accurate, efficient and user friendly.

Power System Analysis, the Load Flow Analysis that performs to gain information of the power and voltage flow in the buses of the power system network in order to evaluate the performance of power system network as well as to analyze any planning for power system improvement under steady state conditions. It is necessary for planning, operation, economic scheduling and exchange of power between different utility.

CHAPTER 2

LITERATURE REVIEW

Electrical power system consists of complex networks that need continual and comprehensive analysis for the planning, design, and operation in order to assist future plant expansion[8]. In power system analysis, the power flow and voltage flow in power system network can be calculated by using three mathematical techniques, the Newton-Raphson method, Gauss-Seidel method and Fast-decouple method[11].

Newton- Raphson method is more practical and efficient for large power system since the number of iterations is independent of the system size but more functional evaluations are required at each iterations[12]. Fast-decouple method makes use of an approximate version of the Newton-Raphson procedure as an alternative strategy for improving computational when solving large power transmission systems[3].

However, hand computational work is almost impossible to perform analysis on large and complex power system network. Therefore, software designed to carry

out the mathematical calculation, or in other words, take over the hand calculation work, which outputs in short time as compared to the conventional method, is available nowadays[1].

2.1 The Utilization of Database in State Determination

The advancement in computer and communication technologies has resulted in the wide usage of the supervisory control and data acquisition (SCADA) system in the modern control centers.[5] SCADA is highly capable and flexible that it deals with large information flows coming from many protective and control devices placed in the bulky electric power systems. [7]

The information is very useful during events that cause outage. It helps the operator in control centers to identify defective part of the system and to start the restoration process. By processing a set of real time redundant measures and network parameters available in the database, the state estimation gets the best estimate of the current system states. [7]

Therefore, the performance of state estimation relies on the accuracy of the measured data as well as the parameters of the networks model. However, there are errors that arise due to the noise or errors in the metering system and the communication process, large error in analog measurements, also known as bad data that may happen in practice, network parameters, impedances of transmission lines for instance, that may be incorrect data in accordance to the inaccurate manufacturing provided data, error in calibration, etc and the lack of field information and possible errors in calculations that transformer tap positions may be erroneous. [9]

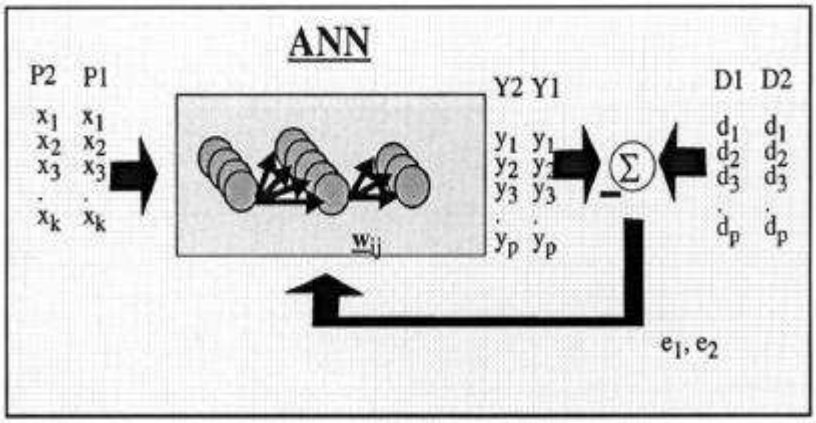
2.2 Artificial Neural Networks (ANNs)

An ANN is most often a nonlinear system that learns to perform a function (an input/output map) from data. It is adaptive, where the system parameters are changed during operation, normally called the training phase. [10] It is built with step-by-step procedure systematically to optimize a performance criterion or to follow some implicit internal constraint, commonly referred to as the learning rule.

The input/output training data are fundamental in neural network technology. They convey the necessary information to discover the optimal operating point. After the training phase the ANN parameters are fixed and the system is deployed to solve the problem at hand. This is called the testing phase. [7]

The nonlinearity of the neural network processing elements (PEs) provides flexibility to the system to achieve practically any desired input/output map. Hence it is said that some Artificial Neural Networks are universal mappers.[13]

For the case of supervised method, an input is given to the neural network while a corresponding target response set is given at the output. Then an error will be composed from the difference between the desired output or response and the system output which is next fed back to the system where it adjusts the parameters of the system systematically according to the learning rule.[7] This process is repeated until the performance is acceptable. The style of computation is shown in Figure 2.1.[4]



The style of neural computation.

Figure 2.1 The style of Neural Computation

The performance of the neural network hinges heavily on the data. Therefore, neural network technology is not a suitable solution for cases where data is insufficient to cover significant portion of the operating conditions or they are noisy. Conversely, it is a good solution to derive an approximate model for conditions where a plenty of data exist but with the problem poorly understood. [13]

Instead of conducting traditional engineering design that exhaustive subsystem specifications and intercommunication protocols are necessary,[4] in artificial neural networks, the designer chooses the network topology, the performance function, the learning rule and the criterion to stop the training phase, but the system adjusts the parameters automatically.

Though it is hard to bring a priori information into the design and it is difficult to incrementally refine the solution when the system does not work in proper way, ANN-based solutions are very time efficient in terms of development and resources. Besides, in many tough problems, it provides performance that is difficult to match with other technologies. Hence, ANNs are emerging as the choice for applications like pattern recognition, prediction, system identification and control.[7]

2.2.1 Advantages and Disadvantages of Artificial Neural Networks (ANNs)

ANNs is a system that takes the operation of biological neural networks as conceptual basis, i.e. it is an emulation of biological neural system. Despite the disadvantages that it is made with, it performs certain tasks that a program made for a common microprocessor is unable to perform. In other words, a neural network can perform tasks that a linear program cannot. [14]

When an element of the neural network fails, its parallel nature enables it to continue without any problem. Besides, it learns and does not need to be reprogrammed. Thus, it can be implemented in any application without any problem. However, the neural network needs training prior to its operation. Its architecture is different from that of a microprocessor; therefore, it needs to be emulated. [15]

In addition, high processing time is required for large neural networks. Artificial neural networks can have different architectures that consequently require different types of algorithms, but it is relatively simpler than to be a complex system.

2.2.2 Mathematical Modeling of ANNs from Biological Model

A biological nervous system consists of neurons as the basic signaling units where each neuron is a discrete cell whose several processes arise from its cell body. The ANNs emerged as circuits that could perform computational tasks with biological neurons as basic conceptual components.